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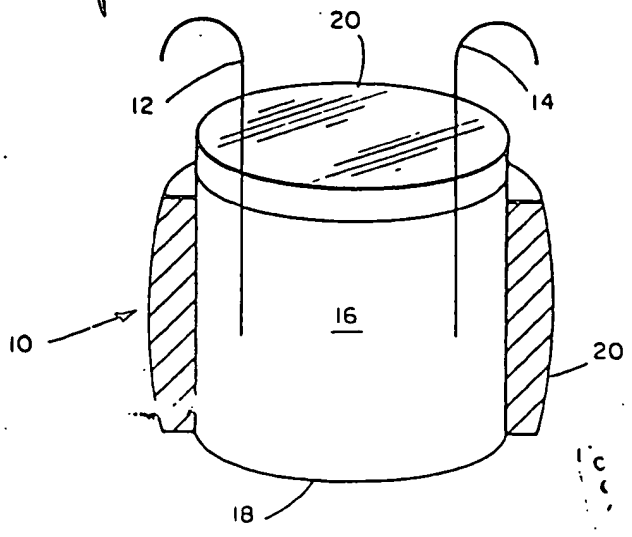
(54) Title: MEDIA FOR SOLID STATE FUSION

(57) Abstract

Media for electrochemical as well as thermochemical fusion apparatuses are provided. Materials systems consisting of deuterium storage intermetallic compound, transition metal/rare earth metal intermetallic compound and elemental material cathodes are combined with compatible electrolytes including solid deuteride electrolytes, cryogenic electrolytes and supercritical deuterium in electrochemical fusion apparatuses wherein a magnetic field may be provided to enhance fusion initiation in the cathode. Magnetic field fusion initiation enhancement is also part of an electrochemical fusion apparatus including a deuterium storage cathode and deuterium containing electrolyte. Thermochemical fusion apparatuses consisting of deuterium storage media and a source of deuterium with magnetic field fusion initiation enhancement are provided. Thermochemical fusion apparatuses consisting of intermetallic compound, transition metal/rare earth metal intermetallic compound or lithium, palladium, or vanadium material for deuterium storage and a source of deuterium which may include supercritical deuterium are provided. A thermochemical fusion apparatus using a titanium deuterium storage material with a supercritical deuterium source is also provided. The invention enables the operation of these electrochemical and thermochemical fusion apparatuses over a wide range of temperatures and pressures which may be adjusted to optimize the efficiency of the solid state fusion reaction.



MEDIA FOR SOLID STATE FUSION

Background of the Invention

This invention provides media for solid state fusion.

Fleischmann and Pons, in a paper to appear in J. that Electroanal Chem. 261, 301 (1989), describe experiments ~~which~~ apparently demonstrate nuclear fusion at room temperature in deuterium-filled palladium rods operated in an electrochemical cell. They report an energy release of 4.5 watts per each watt of input electrical power.

In this experiment, they observe a generation of neutrons and of tritium, an isotope of hydrogen, from electrochemically compressed D^+ in a palladium cathode. Their calorimetric measurements on the system reveal a substantial excess enthalpy generation, exceeding 10 watts/cm^3.

In one experiment, they report that a considerable portion of the palladium cathode fused while another fraction of it vaporized. (Palladium is a noble metal having a melting point of 1554°C.) In this explosion, the cell, its contents and a part of a fume hood in which it was housed were destroyed.

Attempts to synthesize helium from hydrogen using a heated palladium catalyst were reported in the late 1920's by a number of researchers among whom were two German chemists, Fritz Paneth and Kurt Peters (Nature 118, 526 (1926) and Die Naturwissenschaften 14, 956 (1926)).

However, they later retracted this work (Nature 119, 706 (1927) and Die Naturwissenschaften 15, 397 (1927)) asserting that the helium that they had detected had been given off by the glass and asbestos components of their apparatus upon heating in a hydrogen atmosphere. Such experiments were abandoned from the mid-1930's until the recent announcements.

Jones and co-workers have confirmed the existence of cold nuclear fusion in condensed matter in both laboratory

experiments and geological formations (Nature 338, 737 (1989)) Nuclear Fusion in Condensed Matter" by S. E. Jones, et al. These workers observed deuteron-deuteron fusion at room temperature during low-voltage electrolytic infusion of deuterium into titanium and palladium electrodes. They interpret a peak observed at 2.5 MeV in the neutron emission spectrum obtained from this experiment as evidence of a fusion reaction proceeding according to the mechanism of equation 1.

$$^{2}D + {}^{2}D \rightarrow {}^{3}He\ (0.82\ MeV) + n(2.45MeV) \qquad (1)$$

They suggest that piezonuclear fusion may account for the fusion rates observed in condensed matter. Such piezonuclear fusion occurs in the presence of high concentrations of isotopic hydrogen ions maintained under non-equilibrium conditions such as those induced by electrolysis in the cold fusion condensed matter laboratory experiments recently reported.

Scaramuzzi and co-workers (DeNinno et al., Europhysics Letters, preprint) interpreted a high level of neutron emission from titanium shavings exposed to deuterium gas whose pressure and temperature were varied as evidence of cold nuclear fusion. They reported a successful experiment using deuterium gas at elevated pressures and temperatures around 77 K.

Summary of the Invention

Broadly, the invention provides new materials systems that allow access to a wider range of deuterium storage media chemistries for use in fusion apparatuses. Use of alternative classes of materials to serve as deuterium storage media requires simultaneous identification of new classes of materials compatible with these deuterium storage media to serve as the deuterium sources.

Supercritical deuterium, D_2, maintained at its critical point 38.4 K, 1.66 MPa, or other supercritical deuterium bearing media, e.g. DCl, ND_3, and D_2O, can be used as sources of deuterium in thermochemical fusion apparatuses where deuterium storage materials requiring anhydrous environments, such as Li and $LaNi_5$, are also in use. Supercritical deuterium may also provide another anhydrous candidate electrolyte suitable for use with electrode materials unstable in aqueous environments. One such electrode material is lithium (Li) which can be a host for the reaction $D+T \rightarrow {}^4He+n$. Supercritical deuterium is also compatible with $LaNi_5$.

Low temperatures can result in immobilization of the deuterium, making it a "fixed target", in both electrochemical and thermochemical fusion apparatuses. The range of stability of supercritical D_2 extends to cryogenic temperatures and offers this advantage. For electrochemical fusion apparatuses, cryogenic electrolytes such as DCl (melting point 158.2 K, boiling point 191.6 K, N.V. Sidgwick, Chemical Elements and their Compounds V. 1, Oxford University Press, New York and London (1950)) and ND_3 (melting point 199.6 K, boiling point 242.1 K, N.V. Sidgwick, Chemical Elements and Their Compounds V. 1, Oxford University Press, New York and London (1950)) offer similar advantages and are compatible with electrode materials such as Li and $LaNi_5$ which exhibit instability in aqueous environments.

An electrochemical fusion apparatus of the invention consists of a cathode composed of a transition metal/rare earth metal intermetallic compound which can be $LaNi_5$, or of an intermetallic compound which may be Nb_3Al, V_3Ga, Ti_2Co or La_3In, and an electrically conductive anode, both of which are immersed in a deuterium containing electrolyte. Depending upon the temperature and pressure ranges selected for operation of the electrochemical fusion apparatus, this electrolyte can

consist of a solid deuteride electrolyte, a supercritical deuterated electrolyte, or a cryogenic electrolyte. Cryogenic and supercritical electrolytes include DCl and ND_3 solvents whose ionic conductivity can be enhanced by addition of salts. LiD can be added to supercritical D_2 to improve the latter's performance as an electrolyte. Tetramethylammonium chloride ($(CH_3)_4NCl$) is a salt suitable for addition to DCl and potassium cyanide (KCN) and potassium nitrate (KNO_3) are appropriate additives for ND_3. An AC or DC power supply drives the electrochemical fusion apparatus by passing current between the anode and cathode, which in turns drives a faradaic process at the cathode, charging it with deuterium.

In a preferred embodiment, a vessel is provided to contain the cathode, anode and electrolyte. In another embodiment, an electromagnet or a permanent magnet magnetic field generator is disposed exterior or interior to the vessel.

In another aspect of the invention, an electronically conductive deuterium storage material and an electronically conductive anode are immersed in a deuterium containing electrolyte, and polarized. A magnetic field generator can enhance fusion initiation in the electronically conductive cathode.

Other embodiments provide for use of an electronically conductive cathode and anode in conjunction with a solid deuteride electrolyte, supercritical deuterated or cryogenic electrolyte, depending upon the temperature and pressure ranges chosen for operation of the electrochemical fusion apparatus. Cryogenic electrolyte solutions can include DCl and ND_3 solvents whose ionic conductivity can be enhanced by addition of $(CH_3)_4NCl$ to DCl and KCN or KNO_3 to ND_3. LiD can be added to supercritical D_2 to improve its performance as an electrolyte.

According to another aspect of the invention, an electrochemical fusion apparatus consists of a cathode

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material that is inert with respect to chemical reactions with the deuterium bearing solution and does not disable the electrochemical process for deuterium storage and an electronically conductive anode, both immersed in a non-aqueous deuterium containing electrolyte, in which current is made to pass between the anode and cathode with the result that the cathode is charged with deuterium.

Other embodiments allow for use of lithium, palladium or vanadium as cathode materials. Such cathode materials and electronically conductive anodes can be combined with a solid deuteride electrolyte, a supercritical deuterated electrolyte or a cryogenic electrolyte, depending upon the desired temperature and pressure ranges for operation of the electrochemical fusion apparatus. Cryogenic electrolytes can include DCl and ND_3 solvents whose ionic conductivity can be enhanced by addition of $(CH_3)_4$ NCl to DCl and KCN or KNO_3 to ND_3. LiD can be added to supercritical D_2 to improve its performance as an electrolyte. The use of oxygen-free nonaqueous media avoids the formation of a protective oxide film on the cathode material, which, if present, can block deuterium charging. In other embodiments of the invention, the lithium cathode, electronically conductive anode and non-aqueous deuterium containing electrolyte are contained within a vessel.

In other embodiments, this electrochemical fusion apparatus with inert material cathode can include an electromagnet or permanent magnet magnetic field generator disposed interior or exterior to the containment vessel.

In another aspect of the invention, a solid deuteride electrolyte can be confined in a vessel, parts of which function as electrodes.

According to another aspect of the invention, a fusion apparatus consists of a transition metal/rare earth metal intermetallic compound deuterium storage material such as

$LaNi_5$, or an intermetallic compound which can be Nb_3Al, V_3Ga, Ti_2Co, La_3In to serve as the fusion host and a source of deuterium whose physical properties are selected to initiate a solid state fusion reaction. The deuterium source can be supercritical D_2.

In a preferred embodiment, the transition metal/rare earth metal intermetallic compound deuterium storage material and the deuterium source are contained within a vessel.

In other embodiments of the fusion apparatus containing a transition metal/rare earth metal intermetallic compound deuterium storage material, a magnetic field generator such as an electromagnet or a permanent magnet can be used to enhance fusion initiation and may be positioned either interior to or exterior to the vessel.

In another aspect of the invention, a fusion apparatus consists of a deuterium storage material, a source of deuterium whose physical properties have been tuned appropriately to initiate a solid state fusion reaction and an electromagnet or permanent magnet magnetic field generator to enhance fusion initiation in the deuterium storage material.

Other embodiments of the fusion apparatus containing deuterium storage material with magnetic enhancement allow for location of this magnetic field generator either interior or exterior to an optional vessel which contains the deuterium storage material and the deuterium source which can be supercritical deuterium.

In other aspects of the invention, a fusion apparatus consists of lithium, palladium or vanadium material for deuterium storage and a source of deuterium whose physical properties are carefully chosen to initiate a solid state fusion reaction which in a preferred embodiment are contained within a vessel. In other embodiments, fusion in the lithium or vanadium material for deuterium storage is further enhanced by application of a magnetic field by an electromagnet or a

permanent magnet magnetic field generator. The source of deuterium can be supercritical D_2.

In other aspects of the invention, a fusion apparatus consists of titanium material for deuterium storage and a supercritical or deuterated compound source of deuterium, which, in a preferred embodiment, are contained within a vessel. In other embodiments, fusion in the titanium material for deuterium storage with supercritical deuterium or deuterated compound source of deuterium is further enhanced by application of a magnetic field by an electromagnet or permanent magnet magnetic field generator.

Brief Description of the Drawing

In the drawing:

Fig. 1a is a schematic illustration of an electrochemical fusion apparatus including a transition metal/rare earth metal intermetallic compound cathode;

Fig. 1b is a schematic illustration of an electrochemical fusion apparatus including a transition metal/rare earth metal intermetallic compound cathode with an external magnetic field generator;

Fig. 2 is a schematic illustration of an electrochemical fusion apparatus of the invention including an electronically conductive deuterium storage material cathode and an external magnetic field generator;

Fig. 3a is a schematic illustration of an electrochemical fusion apparatus of the invention including a lithium cathode;

Fig. 3b is a schematic illustration of an electrochemical fusion apparatus of the invention including a lithium cathode and an external magnetic field generator;

Fig. 4a is a schematic illustration of a fusion apparatus of the invention including a transition metal/rare earth metal intermetallic compound deuterium storage material;

Fig. 4b. is a schematic illustration of a fusion apparatus of the invention including a transition metal/rare earth metal intermetallic compound deuterium storage material and an external magnetic field generator;

Fig. 5. is a schematic illustration of a fusion apparatus of the invention including a deuterium storage material and an external magnetic field generator;

Fig. 6a is a schematic illustration of a fusion apparatus of the invention including lithium material for deuterium storage;

Fig. 6b. is a schematic illustration of a fusion apparatus of the invention including lithium material for deuterium storage and an external magnetic field generator.

Fig. 7 is a schematic illustration of an electrochemical fusion apparatus of the invention wherein an integral part of a containment vessel serves as an electrode.

Description of the Preferred Embodiment

In Fig. 1a, an electrochemical fusion apparatus 10 includes an intermetallic compound cathode 12, an electronically conductive anode 14, a deuterium containing electrolyte 16, and a power supply (not shown) for passing current between the intermetallic compound cathode 12 and the electronically conductive anode 14. A vessel 18 contains the intermetallic compound cathode 12, the electronically conductive anode 14 and the deuterium containing electrolyte 16. The vessel 18 can be fitted with a cover 20.

The transition metal/rare earth metal intermetallic compound cathode 12 can consist of any transition metal/rare earth metal intermetallic compound such as $LaNi_5$, or can be an intermetallic compound such as Nb_3Al, V_3Ga, Ti_2Co or La_3In. The power supply (not shown) which passes current between the cathode 12 and anode 14 resulting in charging of the cathode 12 with deuterium can provide AC or DC excitation.

The deuterium containing electrolyte 16 can consist of a solid deuteride electrolyte, or a cryogenic electrolyte containing solvents such as DCl or ND_3 whose ionic conductivity is enhanced by addition of $(CH_3)_4$ NCl to DCl and KCN or KNO_3 to ND_3. Supercritical deuterium, deuterium maintained at a temperature in excess of 38.4 K and a pressure in excess of 1.66 MPa, whose performance as an electrolyte has been improved by the addition of LiD, can be used with electrode materials unstable in aqueous environments. The choice of electrolyte will depend upon the desired temperature and pressure ranges for operation of the electrochemical fusion reactor.

An important consideration in selection of a solid deuteride electrolyte is the requirement that the electrolyte allow the intermetallic compound cathode 12 to be charged with deuterium at a rate exceeding the rate of deuterium leakage, where the latter acts to deplete the deuterium content of the intermetallic compound cathode 12. The selection criteria for this solid deuteride electrolyte are parameterized by the following relationship:

$$I_c > D_D \cdot S_D \qquad (2)$$

where I_c is the charging current in deuterium equivalents per second, D_D is the instantaneous diffusivity of deuterium in the cathode material in cm^2/s, and S_D is the saturation solubility of deuterium in the cathode material in deuterium equivalents/cm^2.

In the embodiment of Fig. 1b, the electrochemical fusion apparatus includes a magnetic field generator 20 to enhance fusion initiation in the intermetallic compound cathode 12. Magnetic effects may help to trigger fusion by "shocking" the lattice. The magnetic field generator 20 can consist of an electromagnet or a permanent magnet arranged inside or outside the vessel 18.

An electrochemical fusion apparatus 30 shown in Fig. 2 includes an electronically conductive cathode 32 which can be any electronically conductive deuterium storage material, an electronically conductive anode 34, a deuterium containing electrolyte 36, a power supply (not shown) for passing current between the electronically conductive cathode 32 and the electronically conductive anode 34 and a magnetic field generator 38 which is positioned outside an optional vessel 40 with a cover 42 for containment of the electronically conductive cathode 32, the electronically conductive anode 34 and the deuterium containing electrolyte 36. The magnetic field should be oriented to cause a maximum pinch effect at any place in the cathode.

The electronically conductive cathode 32 can consist of any electronically conductive material. The power supply (not shown) is used to pass current between the electronically conductive cathode 32 and the electronically conductive anode 34 for charging the electronically conductive cathode 32 with deuterium by providing either AC or DC excitation. Depending upon the temperature and pressure ranges of operation chosen for the electrochemical fusion apparatus 30, the deuterium containing electrolyte for higher than room temperature operation 36 can be selected from among solid deuteride electrolytes satisfying the charging requirements set forth previously, supercritical D_2 whose performance as an electrolyte has been enhanced by addition of LiD, other supercritical deuterated electrolytes, or cryogenic liquid electrolytes including DCl and ND_3 solvents whose electrical conductivity can be enhanced by addition of $(CH_3)_4$ NCl to DCl and KCN or KNO_3 to ND_3. These choices for the deuterium containing electrolyte 36 provide flexibility in selection of operating temperature and enable the selection of cathode chemistries that are unstable in aqueous environments.

Figs. 3a and 3b show an electrochemical fusion apparatus 45 that includes a lithium cathode 46, an electronically conductive anode 48, a nonaqueous deuterium containing electrolyte 50, an AC or DC power supply (not shown) for passing current between the lithium cathode 46 and the electronically conductive anode 48, and an optional vessel 52 with a cover 54 for containment of the lithium cathode 46, the electronically conductive anode 48 and the nonaqueous deuterium containing electrolyte 50. The nonaqueous deuterium containing electrolyte 50 for above room temperature operation can be selected from among solid deuteride electrolytes of adequate charging capacity based upon the selection criteria previously described, or for below room temperature operation from among cryogenic liquid electrolytes including DCl and ND_3 solvents whose ionic conductivity can be enhanced by addition of $(CH_3)_4$ NCl to DCl and KCN or KNO_3 to ND_3 and supercritical D_2 whose performance as an electrolyte has been enhanced by addition of LiD. In another embodiment of the electrochemical fusion apparatus 45, shown in Fig. 3b, a magnetic field generator 56 which can be an electromagnet or a permanent magnet is shown positioned exterior to the vessel 52. The magnetic field generator 56 enhances fusion initiation in the lithium cathode 46.

A fusion apparatus 60 of Figs. 4a and 4b includes a transition metal/rare earth metal intermetallic compound 62 for deuterium storage ~~that~~ which can be in powder, pellet or shaving form, and a source of deuterium 64 whose physical properties such as temperature and pressure are selected to initiate a solid state fusion reaction, such as supercritical D_2, which are contained within an optional vessel 66 provided with a cover 68. The transition metal/rare earth metal intermetallic compound deuterium storage material can be $LaNi_5$. The intermetallic compounds Nb_3Al, V_3Ga, Ti_2Co, or La_3In can also serve as deuterium storage media. The physical

properties of the deuterium 64 can be adjusted in order to initiate and maintain the solid state fusion reaction.

The temperature and pressure maintained within the reactor can be adjusted to optimize the fusion reaction. The deuterium 64 can be maintained at a cryogenic temperature, at a temperature between a cryogenic temperature and 25°C, at a temperature greater than 25°C or at its critical point, 38.4 K and 1.66 MPa. The deuterium 64 can be maintained at pressures below or above atmospheric pressure or at atmospheric pressure. The transition metal/rare earth metal intermetallic compound deuterium storage material 62 can be maintained at a cryogenic temperature, at a temperature between a cryogenic temperature and 25°C or at a temperature above 25°C.

In another embodiment of the fusion apparatus 60 (Fig. 4b), a magnetic field generator 70 is positioned external to the containment vessel 66 for enhancement of fusion initiation in the transition metal/rare earth metal intermetallic compound 62.

Fig. 5 shows a fusion apparatus 80 that includes a deuterium storage material 82 ~~that~~ which can be in powder, pellet or shaving form, a source of deuterium 84 whose physical properties are selected to initiate and sustain a solid state fusion reaction, such as supercritical D_2, an optional vessel 86 with cover 88 for containment of the deuterium storage material 82 and the source of deuterium 84, and a magnetic field generator 90 which can be an electromagnet or permanent magnet positioned either interior or exterior to the optional vessel 86 with cover 88. The deuterium source 84 pressure and temperature can be adjusted to best initiate and sustain the solid state fusion reaction. Temperatures can be maintained at a cryogenic temperature, at a temperature between a cryogenic temperature and 25°C, at a temperature exceeding 25°C or at the deuterium critical temperature and pressure. The deuterium can be maintained at atmospheric pressure or at pressures above and

below atmospheric pressure. The deuterium storage material 82 similarly can be maintained at a cryogenic temperature, at a temperature between a cryogenic temperature and 25°C, or at a temperature greater than 25°C.

In the embodiment of Fig. 6a, a fusion apparatus 100 includes lithium material for deuterium storage 102 that can be in powder, pellet or shaving form, and a source of deuterium 104 contained within an optional vessel 106 with cover 108. The pressure and temperature of the deuterium 104 can be adjusted to initiate and sustain the solid state fusion reaction. The deuterium source 104 can be maintained at a cryogenic temperature, at a temperature between a cryogenic temperature and 25°C, or at a temperature greater than 25°C. The source of deuterium 104 can also be supercritical deuterium maintained at 38.4 K and 1.66 MPa. The pressure of the deuterium 104 can be held at atmospheric pressure, above atmospheric pressure or below atmospheric pressure. The temperature of the lithium material for deuterium storage can also be varied to include cryogenic temperatures, temperatures between cryogenic temperatures and 25°C and temperatures exceeding 25°C. In the embodiment of Fig. 6b, the fusion apparatus 100 includes a magnetic field generator 110 which can be positioned exterior, as shown, or interior to the vessel 106 for enhancement of fusion initiation in the lithium material for deuterium storage 102.

Fig. 7 shows a fusion apparatus 110 that includes a solid deuteride electrolyte 114 and a source of deuterium gas 116 which can be either pure D_2 or D_2 in solution with other gases, which is admitted into the fusion apparatus 110 with a valve 118. The solid deuteride electrolyte 114 is in contact on either side with electrodes, a cathode 120 composed of a deuterium storage material where solid state fusion occurs and an anode 122 which is simply an electronic conductor which delivers electrons back to a power supply (not shown) to drive

the faradaic process occurring at an anodic surface 124 of the solid deuteride electrolyte 114. The half reaction occurring on the anodic face 124 is given by $1/2D_2 \rightarrow D^+ + e$ and the reaction on cathodic face 126 is given by $D^+ + e \rightarrow \underline{D}$, where the underline denotes that elemental deuterium is dissolved in the cathode 120. A containment vessel 128 can be composed of an insulating material, impervious to deuterium and deuterons.

What is claimed is:

CLAIMS

1. Electrochemical fusion apparatus comprising:

a cathode comprised of an intermetallic compound deuterium storage material;

an anode comprised of an electronically conductive material;

an electrolyte containing deuterium, in contact with said anode and said cathode;

and a power supply for passing current between said anode and said cathode.

2. Electrochemical fusion apparatus comprising:

a cathode comprised of an electronically conductive deuterium storage material;

an anode comprised of an electronically conductive material;

an electrolyte containing deuterium, in contact with said anode and said cathode;

a power supply for passing current between said anode and said cathode;

and further comprising a magnetic field generator for enhancement of fusion initiation in said cathode.

3. Electrochemical fusion apparatus comprising:

a cathode comprised of a material for deuterium storage ~~which~~ That does not react chemically to disable an electrochemical process;

an anode comprised of an electronically conductive material;

a non-aqueous electrolyte containing deuterium, in contact with said anode and said cathode;

and a power supply for passing current between said anode and said cathode.

4. The apparatus of claim 1, 2 or 3 further comprising a vessel for containment of said cathode, anode and electrolyte.

5. The apparatus of claim 4 wherein said vessel serves as said cathode of said electrochemical fusion apparatus.

6. The apparatus of claim 4 wherein said vessel serves as said anode of said electrochemical fusion apparatus.

7. The apparatus of claim 1 or 2 wherein said cathode comprises one or more intermetallic compounds selected from the group consisting of Nb_3Al, Ti_2Co, V_3Ga or La_3In.

8. The apparatus of claim 1 or 2 wherein said cathode comprises $LaNi_5$.

9. The apparatus of claim 1, 2 or 3 wherein said power supply provides AC excitation.

10. The apparatus of claim 1, 2 or 3 wherein said power supply provides DC excitation.

11. The apparatus of claim 1, 2 or 3 wherein said power supply provides a mixed waveform, i.e. DC with superimposed AC, excitation.

12. The apparatus of claim 1, 2 or 3 wherein said electrolyte comprises a solid deuteride electrolyte.

13. The apparatus of claim 12 further comprising a source of deuterium gas.

14. The apparatus of claim 1, 2 or 3 wherein said electrolyte is a cryogenic electrolyte.

15. The electrolyte of claim 14 wherein said cryogenic electrolyte comprises DCl to which one or more salts have been added to improve ionic conductivity.

16. The electrolyte of claim 14 wherein said cryogenic electrolyte comprises ND_3 to which one or more salts have been added to improve ionic conductivity.

17. The electrolyte of claim 15 wherein said salts comprise tetramethylammonium chloride $(CH_3)_4$ NCl.

18. The electrolyte of claim 16 wherein said salts comprise KCN or KNO_3.

19. The apparatus of claim 1, 2 or 3 wherein said electrolyte is a supercritical deuterium bearing medium.

20. The apparatus of claim 19 wherein the electrolyte performance of said supercritical deuterium bearing medium is improved by the addition of LiD.

21. The apparatus of claim 1 or 3 further comprising a magnetic field generator to enhance fusion initiation in said cathode.

22. The apparatus of claim 2 wherein said magnetic field generator is disposed exterior to said vessel.

23. The apparatus of claim 21 wherein said magnetic field generator is disposed exterior to said vessel.

24. The apparatus of claim 2 wherein said magnetic field generator is disposed interior to said vessel.

25. The apparatus of claim 21 wherein said magnetic field generator is disposed interior to said vessel.

26. The apparatus of claim 2 wherein said magnetic field generator is an electromagnet.

27. The apparatus of claim 21 wherein said magnetic field generator is an electromagnet.

28. The apparatus of claim 2 wherein said magnetic field generator is a permanent magnet.

29. The apparatus of claim 21 wherein said magnetic field generator is a permanent magnet.

30. The apparatus of claim 3 wherein said material for deuterium storage comprises one or more elements selected from the group consisting of Li, Pd, Ti or V.

31. Fusion apparatus comprising:

an intermetallic compound deuterium storage material; and

a source of deuterium whose physical properties are selected to initiate a solid state fusion reaction.

32. Fusion apparatus comprising:

a deuterium storage material;

a source of deuterium whose physical properties are selected to initiate a solid state fusion reaction; and

further comprising a magnetic field generator for enhancement of fusion initiation in said deuterium storage material.

33. Fusion apparatus comprising:

lithium material for deuterium storage; and

a source of deuterium whose physical properties are selected to initiate a solid state fusion reaction.

34. Fusion apparatus comprising:

palladium material for deuterium storage; and

a source of deuterium whose physical properties are selected to initiate a solid state fusion reaction.

35. Fusion apparatus comprising:

vanadium material for deuterium storage; and

a source of deuterium whose physical properties are selected to initiate a solid state fusion reaction.

36. Apparatus of claim 32, 33, 34 or 35 further comprising a vessel for containment of said deuterium storage material and said deuterium.

37. The apparatus of claim 31 or 32 wherein said deuterium storage material comprises one or more intermetallic compounds selected from the group consisting of Nb_3Al, V_3Ga, Ti_2Co, La_3In, or $LaNi_5$.

38. The apparatus of claim 31, 33, 34, or 35 further comprising a magnetic field generator to enhance fusion initiation.

39. The apparatus of claim 32 wherein said magnetic field generator is disposed exterior to said vessel.

40. The apparatus of claim 38 wherein said magnetic field generator is disposed exterior to said vessel.

41. The apparatus of claim 32 wherein said magnetic field generator is disposed interior to said vessel.

42. The apparatus of claim 38 wherein said magnetic field generator is disposed interior to said vessel.

43. The apparatus of claim 32 wherein said magnetic field generator is an electromagnet.

44. The apparatus of claim 38 wherein said magnetic field generator is an electromagnet.

45. The apparatus of claim 32 wherein said magnetic field generator is a permanent magnet.

46. The apparatus of claim 38 wherein said magnetic field generator is a permanent magnet.

47. The apparatus of claim 31, 32, 33, 34 or 35 wherein said source of deuterium is maintained at a cryogenic temperature.

48. The apparatus of claim 31, 32, 33, 34 or 35 wherein said source of deuterium is maintained at a temperature between a cryogenic temperature and 25°C.

49. The apparatus of claim 31, 32, 33, 34 or 35 wherein said source of deuterium is maintained at a temperature greater than 25°C.

50. The apparatus of claim 31, 32, 33, 34 or 35 wherein said source of deuterium is maintained at a pressure below atmospheric pressure.

51. The apparatus of claim 31, 32, 33, 34 or 35 wherein said source of deuterium is maintained at a pressure above atmospheric pressure.

52. The apparatus of claim 31, 32, 33, 34 or 35 wherein said source of deuterium is maintained at its critical temperature and pressure.

53. The apparatus of claim 31, 32, 33, 34 or 35 wherein said source of deuterium is maintained at atmospheric pressure.

54. The apparatus of claim 31, 32, 33, 34 or 35 wherein said deuterium storage material is maintained at a cryogenic temperature.

55. The apparatus of claim 31, 32, 33, 34 or 35 wherein said deuterium storage material is maintained at a temperature between a cryogenic temperature and 25°C.

56. The apparatus of claim 31, 32, 33, 34 or 35 wherein said deuterium storage material is maintained at a temperature greater than 25°C.

57. Fusion apparatus comprising:
titanium material for deuterium storage; and
a source of supercritical deuterium.

58. Fusion apparatus comprising:
titanium material for deuterium storage;
and deuterium containing compound source of deuterium.

59. The apparatus of claim 57 or 58 further comprising a magnetic field generator to enhance fusion initiation.

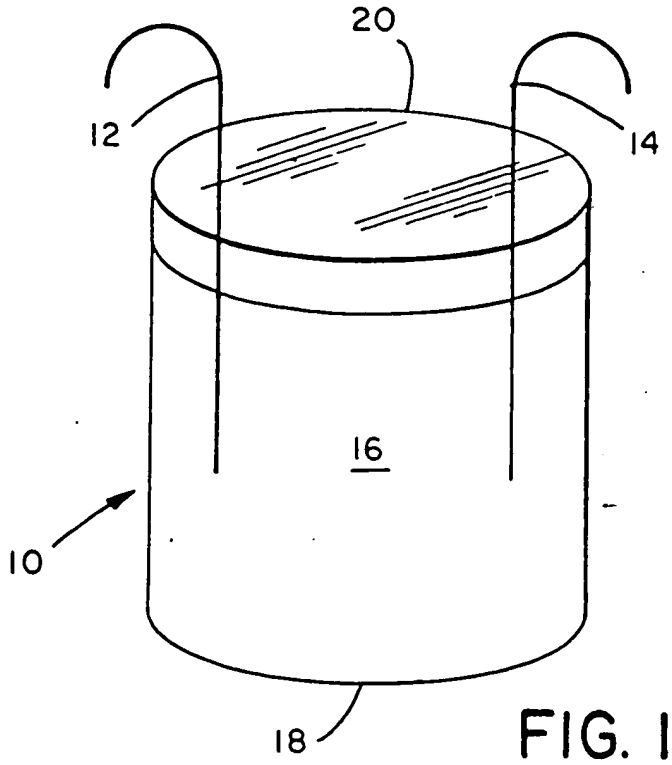

FIG. 1a

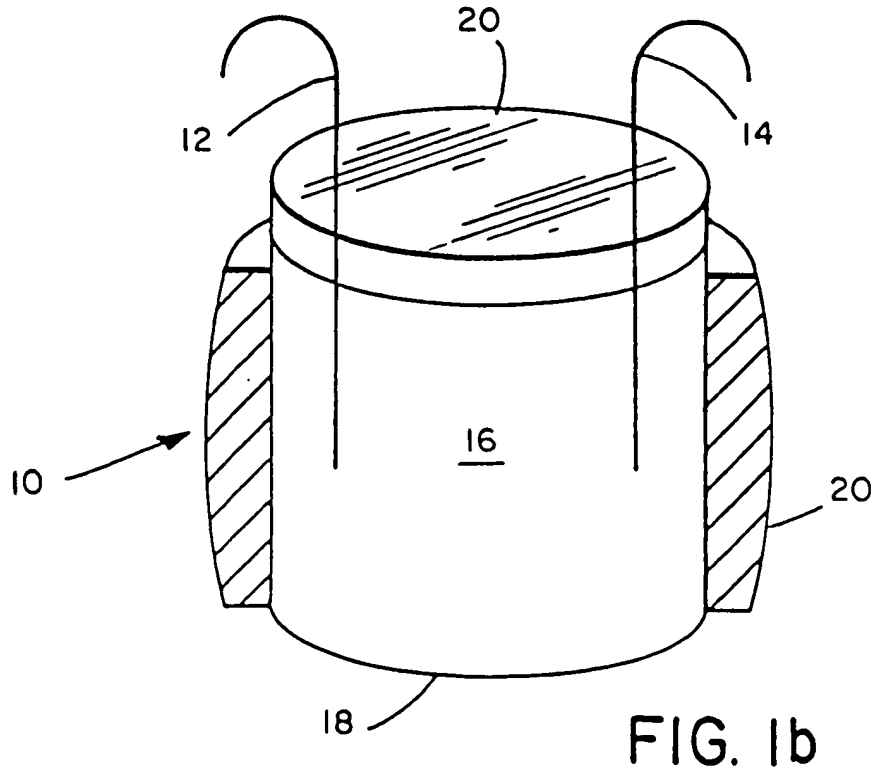

FIG. 1b

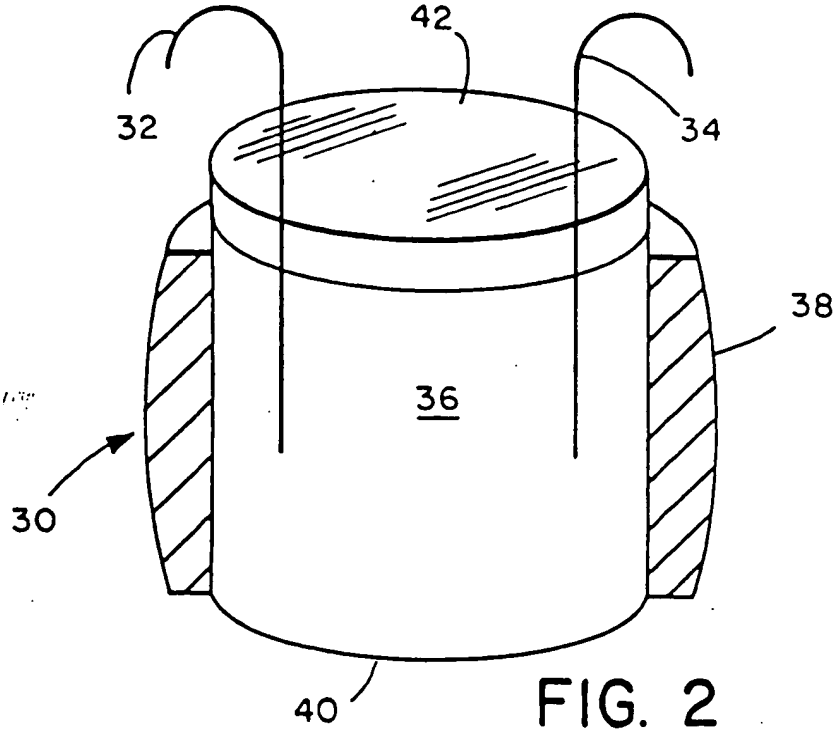

FIG. 2

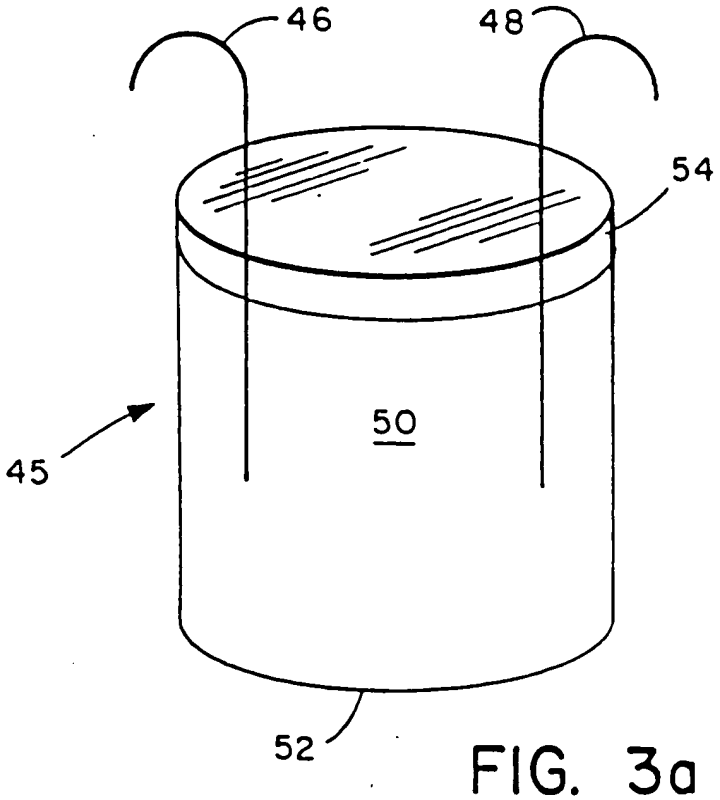

FIG. 3a

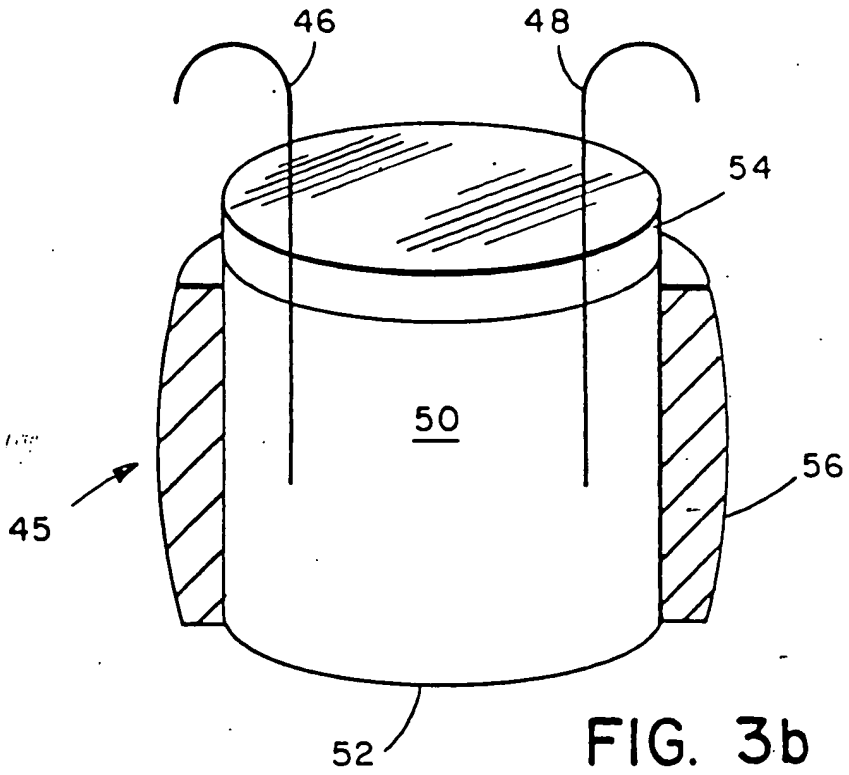

FIG. 3b

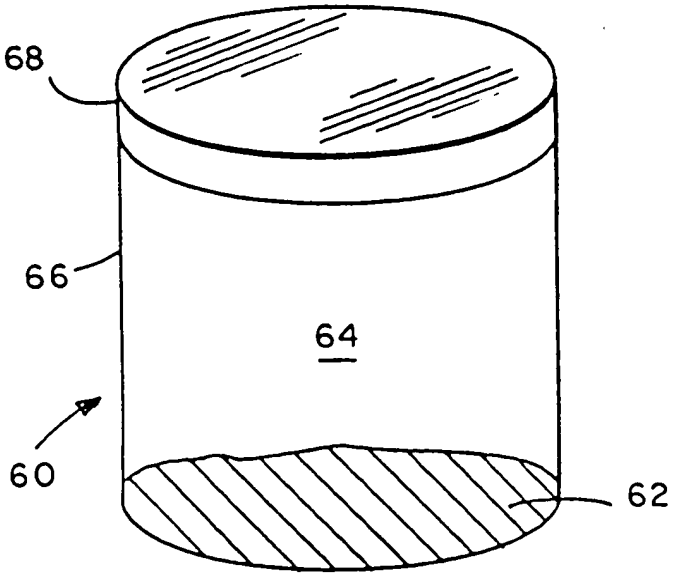

FIG. 4a

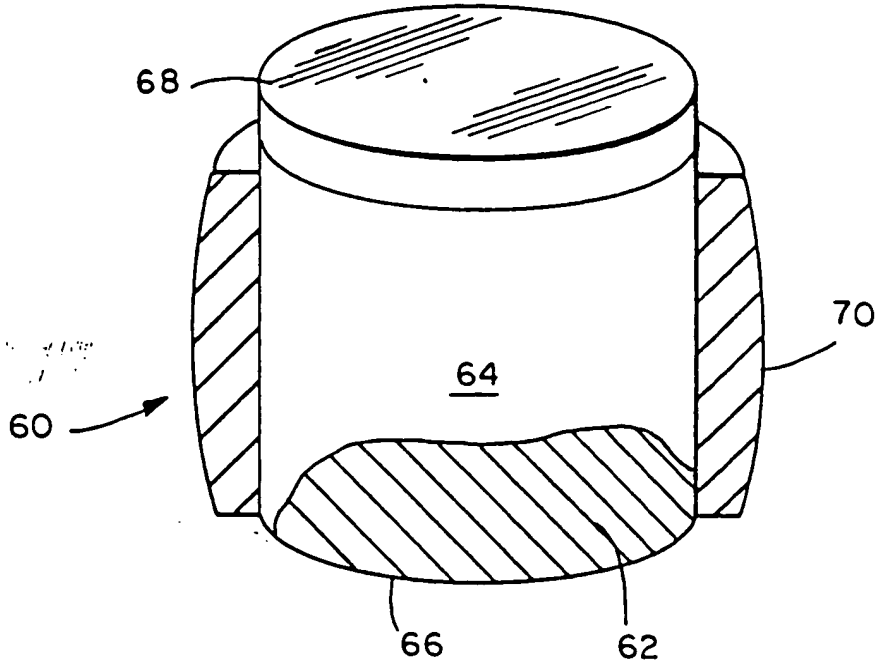

FIG. 4b

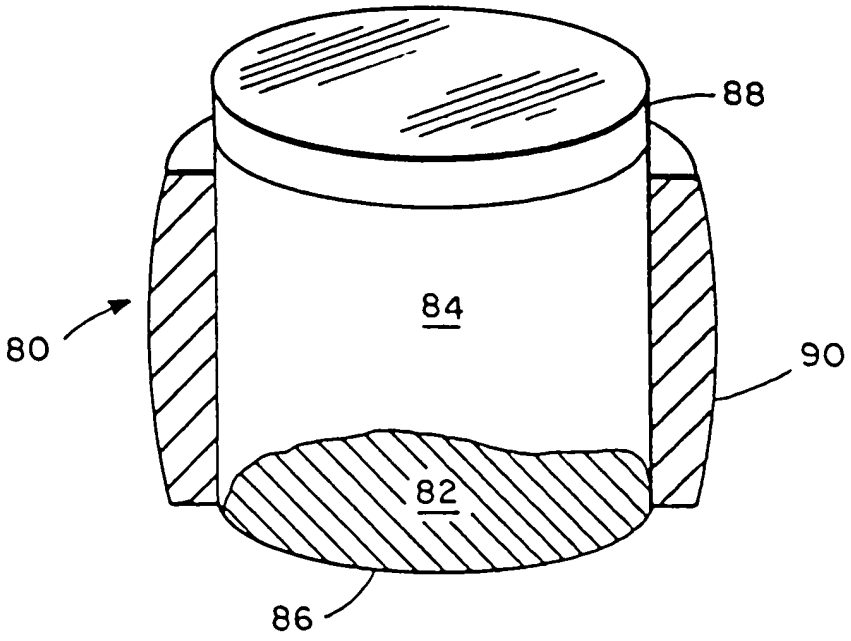

FIG. 5

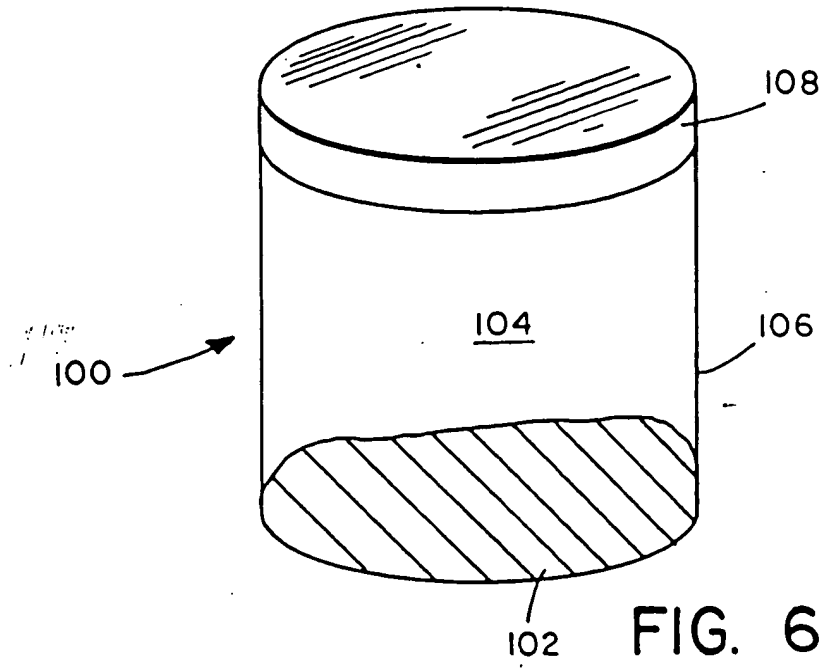

FIG. 6a

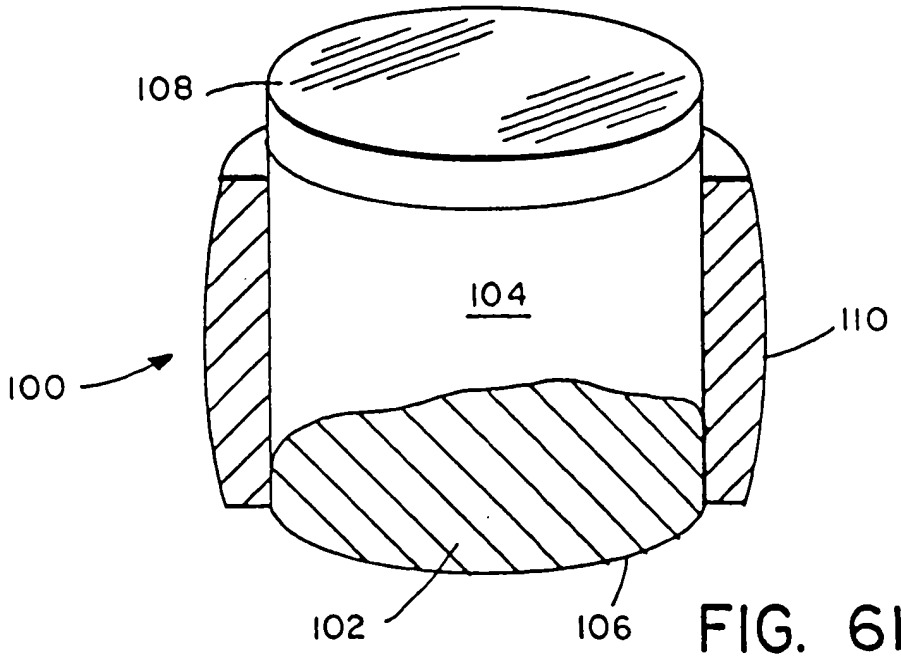

FIG. 6b

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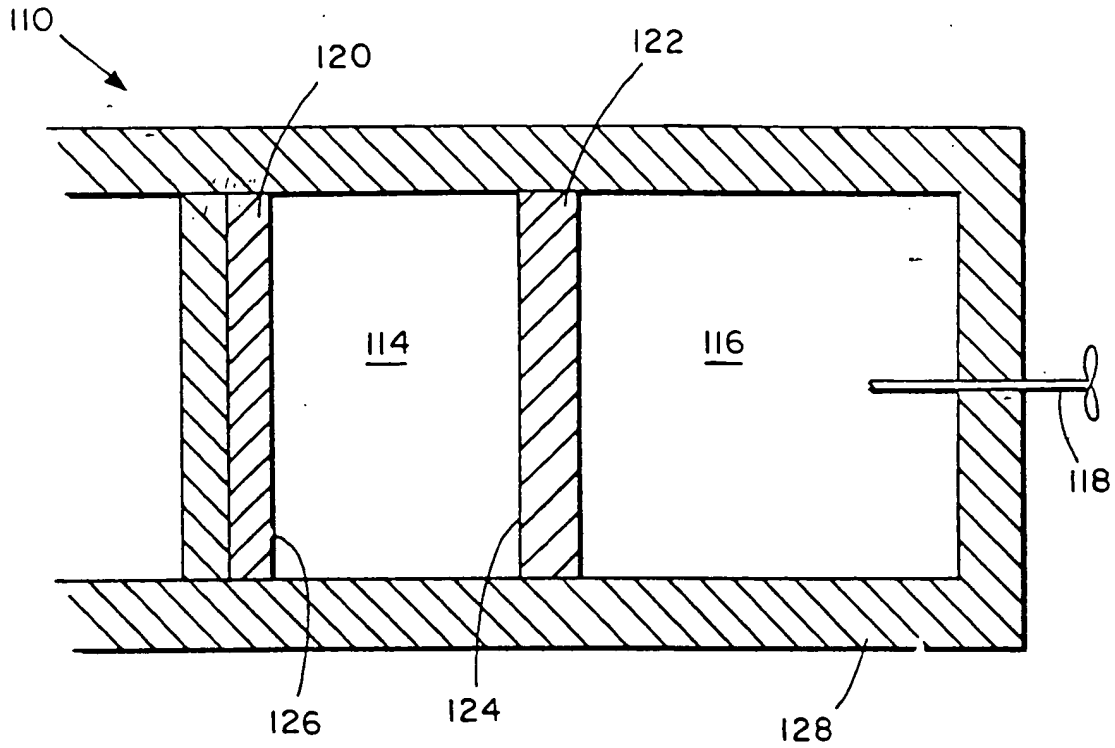

FIG. 7